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(54) Process and apparatus for drying ceramic blanks

(57) The purpose is to provide, in order to ensure the highly economical drying of ceramic blanks, an automation solution which can be adapted to practical conditions of operation and which will enable subjective factors to be largely eliminated and the drying to be carried out in accordance with a criterion valid for all parameters, from the initial to the final parameters, and with freely programmable automatic drying chamber conditions, with documentation of the sequence of operations.

The drying operation is controlled by a computer in three phases, the criterion adopted for the control being the mass of the ceramic blanks, which is measured by dynamometric devices suitable in the form of electronic pressure cells, and with the evaluation of the readings of measuring sensors, the temperature in the dryiing chamber and the mass of the ceramic blanks is determined, the gradient of the moisture reduction is calculated and the rate of the drying operation determined, a drying chamber complex being detected and controlled in time sequence by a central control unit.

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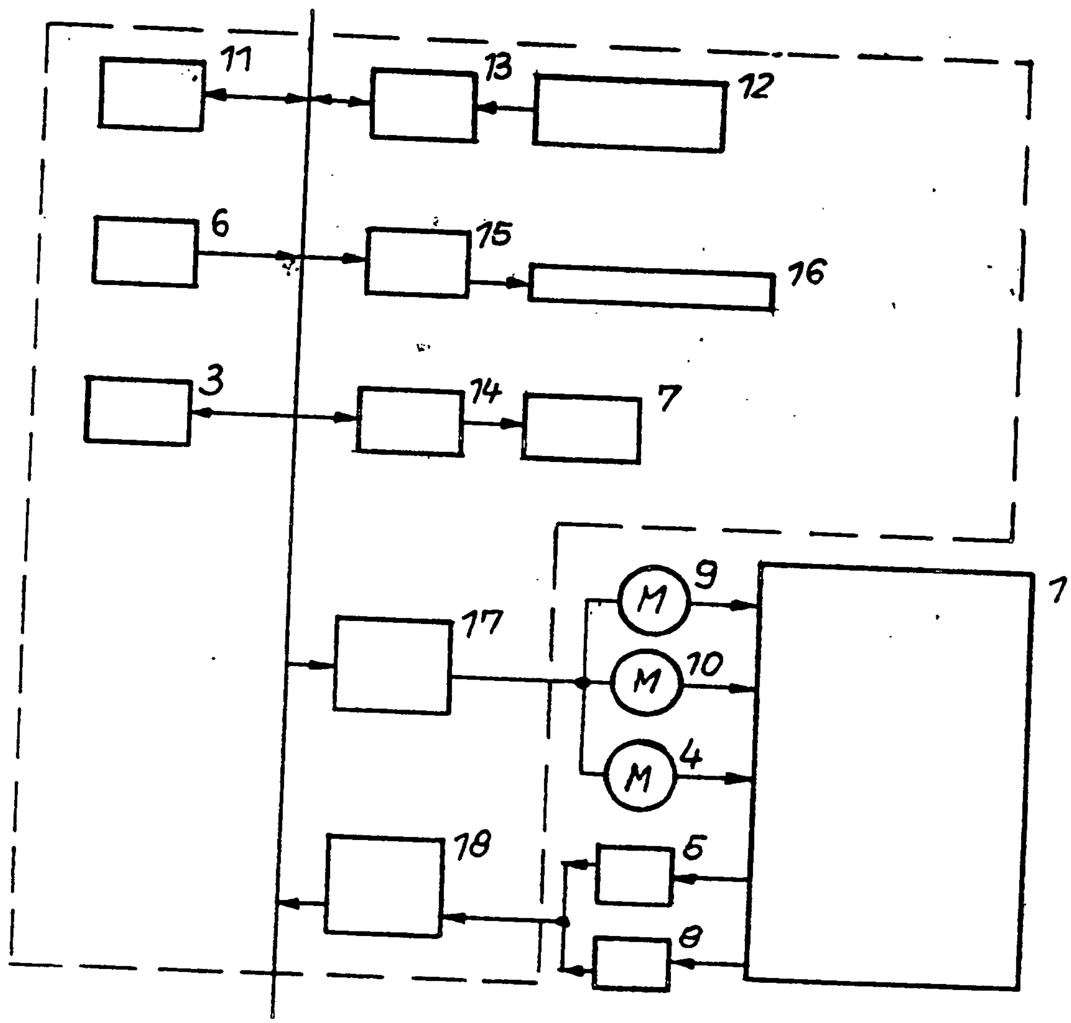

SPECIFICATION

Process and apparatus for drying ceramic blanks

The invention relates to a process for drying ceramic blanks, for example bricks, in chambers, and to an apparatus for the performance of the process.

Processes for the production of bricks or other ceramic products mainly consist of three phases, i.e. shaping the clay material, drying the shaped articles and stoving the dried bricks or the like.

The phase in which the ceramic material is shaped involves the use of conventional equipment, such as presses or nozzles, by a so-called wet method, with the possible use of steam, or with the application of a dry technique, utilizing the humidity of the ceramic material itself for the purpose of shaping it, accompanied by an appropriate shaping pressure.

For the ceramic products shaped by either of these two methods a certain drying time has to be observed so that most of the kneading water and hygroscopic water contained in the products is removed. This operation is required in order to give the unstoved bricks or the like a certain compactness and tenacity, required for their subsequent processing and for feeding the burning-in ovens, so that no deformations will occur, and also in order to avoid fissures, cracks and fractures which certainly occur if the water were removed too rapidly from the wet ceramic articles by introducing them into the said ovens immediately after the shaping process.

The drying of the bricks or the like can be carried out by a natural method or artificially. The natural drying of the shaped bricks etc. by simply exposing them to the external air is no longer adopted, because the cost of storing and fetching the materials is excessive end because the production of the finished article would depend on weather conditions.

Artificial drying is carried out in intermittently fed static chamber dryers or more frequently in tunnel dryers operating continuously. To effect the desired drying of the bricks or other objects the drying medium used consists of a current of hot air generally moving in the opposite direction to the articles to be dried.

The known drying process for ceramic articles suffers from technical and economic drawbacks which have hitherto not been surmounted.

To produce the desired heat exchange conditions and remove the layer of steam surrounding the bricks or the like a considerable quantity of a circulating current of hot air and/or a high speed for the current of hot air is/are required in the interior of the dryer used.

The operation of fans mounted outside or inside the dryer therefore called for a considerable amount of energy in order to ensure an adequate throughput of hot air. For the following reasons, furthermore, the temperature difference between the drying air and the bricks etc. to be dried is invariably too small:

The temperature of the bricks, etc., when they are placed in the dryer, is comparatively low.

The heat exchange between the hot air and the bricks, etc. to be dried takes place in a counterflow.

Towards the end of the drying operation the bricks, etc. can only withstand a very moderate supply of heat to the surface, because they are in a phase in which the diffusion of water in the form of steam is taking place within a porous material and the volume of steam is about 10 times as great as that of the water in its liquid form.

If, therefore, the quantity of heat supplied to the bricks, etc. on the surface exceeds a certain preselected maximum, this causes them to crack.

The drying thus mainly consists of a heat exchange which takes place through forced convection, the most effective drying depending on the value of the hot-air circulation and on the speed of this air.

A further technical drawback resides in the fact that the temperature prevailing when the dryer is being fed, i.e. about 25-40°C, the water contained in the form of moisture in the inburnt bricks, etc. has a high degree of viscosity, resulting in a considerably combining force between this water and the bricks, etc.

The bricks or similar ceramic products therefore undergo surface drying accompanied by relative surface shrinkage while retaining their interior moisture.

The extent of the shrinkage difference ocurring between the outer and the inner part of each brick or similar object causes considerable stresses in this latter which may cause permanent deformation, microfission or even actual breakage.

The danger of micro-fission is also intensified by the phenomenon known as thermoosmosis, mainly consisting of migration of the water from the hot zone on the surface of each brick, etc. being dried towards its colder inner zones.

Owing to the time and energy consumed in drying brick blanks many tests have been carried out for the purpose of finding a way of shortening the time and reducing the energy involved, for every step to accelerate the drying process enables the bricks to be produced more economically, this being directly reflected in noticeable reductions of costs.

Attempts have also been made to accelerate the process by heating the crude blanks prior to the drying operation. These experiments, however, have not given any satisfac-

tory results, in addition to which they prove expensive by reason of a supplementary heating plant having to be supplied and the hours of labour and amount of heating energy involved in the heating process.

Among further known additives used for the purpose of reducing the shrinkage ocurring in the drying are ground calcium carbonate, calcium oxide, cement and crushed slag.

German Patent Specification DE-OS 2009909 describes a process for reducing the drying time for crude brick blanks of clay, particularly loam, in which the physical properties of the "water casing" of the mixing water are influenced in such a way as to modify the adhesion of viscosity.

This is done by giving the clay, before the shaping of the crude blanks, an addition of mineral oil or a mineral oil distillation product or a mineral oil distillate residue, equivalent to 0.5-10% of the weight of the clay, or an addition of di-, tri- or polysaccharide, equivalent to 0.1-5% of the weight of the clay.

Another method is known from German Patent Specification DF-OS 2405087, which describes a method for guiding the air and controlling the values of its state in intermittently fed dryers for ceramic products.

The process is intended to enable a tunnel dryer or channel dryer to be opersted with a low rate of heat consumption. This object is achieved by superimposing currents of circulating air on the flow of dry air, perpendicularly to the direction of transport, while after the end of the charging period the state of the exhaust air is altered in such a way that with approximately constant relative humidity the abaolute humidity is caused to increase with the temperature of the blank on the inlet side.

This solution can only be adopted with dryers consisting of a number of drying channels connected up in succession. It cannot be applied to chamber-type dryers.

The purpose of a process and apparatus described in German Patent Specification DE-OS 2547400 for the drying of ceramic semi-finished products is to dry them In a highly satisfactory manner with the minimum possible consumption of heat.

This is done by "layering" the ceramic aemifinished product, particularly bricks, to form columns, then causing the pre-heated drying air to sweep round them, in each case placing a further semi-finished product on each column after removing a dried semifinished product from the bottom of the column. The apparatus consists of a drying chamber in which drying air flows around the semi-finished products and is characterized by the fact that between horizontal pipes for the drying air and vertical spacer bars vertical shafts are formed for columns of the semi-finished products to be dried and that the drying apparatus and drying chamber are provided at the top and at the bottom apertures through which the shafts are fed with the products and through which the dried material is extracted at the bottom, respectively.

The drying operation carried out in superimposed rows of semi-finished products built up in columns ensures particularly intensive utilization of the drying energy without recourse to a conveying system. The moisture content of the drying air ascending in the column is adapted to that of the semi-finished products to be dried, so that the drying air fed in at the bottom in a completely dry state can continue to absorb moisture throughout its course towards the top.

The purpose of a process for the production of ceramic articles described in German Patent Specification DE-OS 2905748 is to arrange a method for the production of ceramics, bricks and similar articles so that all the drawbacks from which the known methods are found to suffer will be overcome, the drying times required for the ceramic articles being nevertheless shorter than those involved in the processes known.

This problem is solved as a result of the fact that the ceramic articles, when being fed to the dryer or immediately thereafter, are heated up to 100°C, while during this heating operation their moisture content remains approximately equal to that of the ceramic articles at the commencement of the heating phase.

It is considered of advantage if the ceramic products are heated up to a temperature between 40°C and 100°C (dew point) and if this is done in an environment in which the water is at a high partial pressure.

In particular, the ceramic products can be heated up to a dew point between 40°C and 100°C by a current of hot air having a temperature of 120°-140°C and a mnisture content of between 48 and 850 g per kg of drying air. Owing to the known "cold wall principle" the heating of the ceramic products. carried out in an environment in which the water is at a high partial pressure, causes the steam to condense on the surface of each ceramic article, with the subsequent emission of the condensntion heat. The ceramic product is therefore evenly heated over its entire aurface and internally, this taking place before the evaporation of the water on the surface commences. This occurs because during the first phase of the process the flow of heat penetrating the interior of the ceramic product itself increases. This fact is due to the high partial pressure of the water and therefore to the high heat exchange coefficient prevailing in the space in which the heating takes place, this heat exchange coefficient being 10 to 100 times greater than the coefficient occurring in hot air dryers of the customary type.

The control of the partial pressure reached by the water and the control of the tempera-

ture during the drying of the ceramic products call for the fulfilment of certain essential conditions in the operation of such a drying process. With each ceramic unit, needless to say, the entering flow of heat and the emerging water or flow of steam have to be balanced out; this is done both in accordance with the various drying phases and in accordance with the characteristics of the ceramic product concerned, such as its porosity, shape, thickness, mechanical strength, etc. Such controls are carried out by not only influencing the quantities of air and the quantities of fuel consumed inside or outside the dryer and/or recirculation of used smoke belonging to the dryer itself but also and in particular by injecting steam and/or sprayed water into the dryer itself, so that the desired temperature and humidity conditions aforementioned for the drying will be duly obtained. This undoubtedly satisfactory and useful process is directed only to a reduction of the drying time, while the heating energy and electrical energy required for the drying, being dependent on the time elapsing, remain somewhat subordinate thereto.

The process described in German Patent Specification DE-OS 2934420 and the relevant apparatus for the production of bricks deals more with the functional aspect of brick manufacture. Its purpose is to provide a brick producing process and apparatus of which the functional and constructional characteristics will enable the drawbacks of the prior art to be overcome. For the solution of this problem a brick manufacturing process is provided in which the drying phase and the stoving phase take place in a single apparatus into which the fresh mouldings are inserted, preferably in a single layer, the process involving the following further steps:

Pre-heating the fresh mouldings in the inlet zone of the apparatus up to a temperature of 45-100°C, this pre-heating being carried out by means of a current of hot gas having a preselected moisture content and caused to move in the same direction as the said mouldings.

Drying the pre-heated mouldings by means of a further current of hot gas guided in the same direction as the moving product, this current of hot gas being formed by the waste gases of the preheating phase prior to entry into the kiln.

Recirculation of the waste gases, part of them being guided to the inlet to the plant, there forming the current of hot gas for the pre-heating of the fresh mouldings, another part of the waste gases being recirculated for the cooling phase of the completely stoved bricks and there enriched with a preselected quantity of cold air, while finally a further part of the said waste gases is discharged to the chimney.

This process is unfortunately only feasible with so-called tunnel furnaces but cannot be applied in the case of chamber-type dryers. Considerable attention, however, is paid to a process for the manufacture of ceramic products which is described in German Patent Specification DE-PS 2832896. This solves the problem of drying ceramic products of different shape and material with uniform efficiency and nevertheless without damaging them. The solution adopted is as follows: Process for the manufacture of ceramic products hy shaping them from a plastic mass, subsequent drying by initial internal supply of heat and later external supply of heat and subsequent stoving for the purpose of sintering, accompanied by continuous movement of the shaped products, characterized by the fact that the supply of heat from the inside is terminated when the maximum hygroscopic humidity is reached, the supply of external heat commenced after the termination of the shrinkage in the product and continued until equilibrium humidity is reached, and the intensity of the supply of heat being selected to ensure that the moisture is not given off at a speed exceeding 0.5% / min.

According to the foregoing teaching the drying process can be sub-divided into three stages, during the first of which heat is only supplied internally, this being followed by the supply of heat internally and externally simultaneously, the final supply of heat being effected solely externally.

The moments selected for the change-over from one stage to the next are the same for all shapes and materials and guarantee maximum drying efficiency without damaging the product. In this process the initial internal supply of heat is obtained without heating the product in its entire volume, the outer layers of the product having a lower temperature than the inner layers, owing to the evaporation of the moisture. The temperature gradient and the humidity gradient take the same direction, thus ensuring more rapid emission of moisture.

The decreasing internal humidity results in a decrease in the heating intensity through the supply of heat from the inside and thus also in the temperature gradient from the inside towards the outside. When that degree of humidity has been reached at which the shrinkage of the product is terminated and the supply of external heat then commenced, the temperature gradient reverses and the emission of moisture is further accelerated. When the humidity has then decreased still further and has reached the maximum hygroscopic humidity the supply of internal heat is no longer effective, the supply of external heat then being the only remaining means of maintaining a favourable degree of efficiency.

When the products have reached equilibrium humidity further drying serves no purpose. The intensive supply of heat to the products accelerates the drying process but also in-

volves, if a certain maximum speed for the emission of moisture is exceeded, the danger that the product will be destroyed in consequence of the internal stresses occurring.

The speed at which moisture is given off in the drying process may therefore be allowed to vary but most not exceed 0.5% / min. The problem of the supply of heat from inside was solved by causing an electric current to pass through the blanks. In another example this was effected by the aid of high-frequency currents.

All these directions for technical action, which have undoubtedly been amply clarified from the physical point of view, have one factor in common, inasmuch as they only indicate the final or intermediate states but do not indicate how and by what means the limit values are measured or determined in each case. With pyrometric and pychrometric measurements of the kind known *per se* it is as a rule only "space state values" that can be determined, by which, in conjunction with the time measurement and empirical values, the presumable state of the material to be dried is estimated.

By a time program setting means in conjunction with the temperature and humidity values the apparatus can then be switched off by a regulator.

Unfortunately a solution of this kind fails to take account of the frequently fluctuating parameters, such as the mass of the blank or its humidity, the compensation of which, in the chamber, requires widely varying period of time and/or energy consumption rates.

The result is that in order to ensure the prescribed residual moisture in the dried brick or similar product, long drying times are adopted, with a corresponding consumption of energy. This renders production less economical.

The purpose of the invention is to provide, for the highly economical drying of ceramic blanks, an automatic solution adapted to practical operating conditions and enabling subjective factors to be largely eliminated and the whole of the drying process to be documented.

The object of the invention is to provide a process and apparatus enabling the drying of ceramic blanks to be carried out by an automatic chamber drying method freely programmable for all parameters occurring from the beginning to the end of the process, the sequence of operations being logged in actual records.

According to one aspect of the invention there is provided a process for drying ceramic blanks involving a multi-phase drying operation, the process comprising heating ceramic blanks in a drying chamber relatively slowly to a programmable temperature $\upsilon 1$ in a first drying phase without any air change in the drying chamber, effecting further heating of the ceramic blanks and initial removal of moisture by a controlled air change in a second drying phase, the gradient of the moisture removal being used as a guide value and in a third drying phase extracting the residual moisture still present relatively rapidly from the ceramic blanks and terminating the drying process under suitable energy consumption conditions, wherein the first drying phase commences with an empty open drying chamber, in such a way that by a control computer, measuring means in the drying chamber are tested for their operating efficiency, the initial state being determined and recorded, and then the ceramic blanks are introduced into the drying chamber and in order to heat them relatively slowly to a temperature of υ without air change the operating means of the drying chamber are switched on, in which process, by an electrical dynamometer, the mass of the ceramic blanks within a representative zone in the drying chamber is automatically determined, the initial mass of the ceramic blanks being calculated from the values measured and the starting time determined and in parallel therewith the resulting values obtained are logged, and air circulation means, e.g. motors for air circulation, in the drying chamber is operated cyclically by a control program until the drying chamber is automatically switched off, while a heat exchanger associated with the drying chamber and serving to heat the circulating air is subjected for a programmed time t_1 (e.g 0 ...7h) to a programmable power P_1 (e.g. 0 ...100%) by an associated adjusting valve V_1, after the elapse of which said time the heat exchanger is set to a programmable power P_2 (e.g. 0 ...100%), this process being maintained until the average circulating air temperature of the drying chamber has reached a programmable temperature υ 1 of (0...100°C), and when this temperature is reached the process time which has elapsed is determined and logged and the control conditions of the second drying phase are commenced in such a way that the adjusting valve V_1 is set to a programmable value P_3 (e.g. 0 ....100%), an air change device which is provided being opened further, by an adjusting device V_2, in programmable steps S_1 (e.g. 0 ...100%) and at time intervals t_2 (e.g. 0-100) minutes, until the programmable gradient G_1 of the removal of moisture per unit time (e.g. 0....5% of the moisture/h) is reached, and from this moment, at which the process time is logged, the adjusting device V_2 is moved in small steps, in order to maintain the selected value for G_1, and the second drying phase is completed by the calculated residual moisture $F_{(t)}$ having reached a programmed value F_1 (e.g. 0...15%), while the moist air leaving the drying chamber is conveyed through an air outlet shaft above the roof of the chamber, the air conveyed to the drying chamber being taken from a channel into which spent air

from the other drying chambers which are then in the third drying phase and are giving off relatively dry warm air, and when the value F_1 is reached the process time is logged and the transition to the third drying phase commences by the value V_1 being set to a programmable value P_4 (e.g.0....100%) and the adjusting device V_2 for the air change to a fixed position L_2 (e.g. 0...100%), and the drying process is continued with these parameters until the residual moisture which can be calculated for the ceramic blanks has reached a programmable value F_2 (e.g. 0...15%), after which the valve V_1 is adjusted to a zero value and the drying continued until residual moisture F_3 (e.g. 0...15%) is reached, the drying cycle thus being terminated, while the process time, residual moisture F_3, date, time, temperature and drying chamber number are logged and printed out.

According to another aspect of the invention there is provided an apparatus for carrying out the process including as means for measuring the temperature in the drying chamber two thermometer probes provided at different heights in the drying chamber and for determining the humidity value in the ceramic blanks a column of the drying chamber structure contains an electronic dynamometer device preferably taking the form of electronic pressure cells, and as a data acquisition means an electronic control computer and a chronometer of quartz accuracy, being connected with measuring means and control elements, and for controlling the air and air circulation and the valves there are provided motors and servo-motors fitted with revertive signal potentionmeters which are connected to the control computer, and the electronic control computer includes a central processing unit, a fixed-value store for control and regulating programs, a variable value store for control data, an adapter unit for a keyboard, an input keyhoard, a screen display adapter unit and a screen display or a punctiform display, an adapter unit for a teleprinter and a printer and also an adapter unit for regulating elements such as for instance valves, relays, motors, an adapter unit for measuring means, such as for instance semi-conductor thermometer probes and pressure cells, which central control apparatus is Adapted to interrogate or activate the measuring means of a drying chamber complex and its adjusting devices at different times.

The invention will be explained in greater detail by reference to an example illustrated by the accompanying drawing.

The drawing shows a block diagram of the control computer structure and also one of the drying chambers, adopting the example of a drying chamber 1 with its measuring and adjusting devices.

All drying processes hitherto known for ceramic blanks were usually controlled by subjective varying factors and other empirical values. From such empirical values, however, it is not possible to derive those measuring values which are essential for the automation of the required drying process. Automatic drying technology is only feasible if clear target parameters and guide parameters which unambiguously lead to them as well as a reliable measurable criterion applicable throughout the entire drying process are provided and rendered measurable.

For the drying technology for ceramic blanks in accordance with the invention a measurable control criterion is the amount of humidituy contained in the blanks concerned. Its magnitude is measured from the weight of the ceramic blanks from the entry into the drying chamber 1 during the drying process until its completion, which is determined from the weight or from the difference between the weight at the beginning and the weight at the end of the process. The percentage of the moisture content of the ceramic blanks resulting from the kneading and shaping process is known and is included as a fixed value in the control process.

The drying technology for the ceramic blanks is carried out in three phases. The difference as against the known multi-phase drying technologies resides in the fact that the technology according to the invention is controlled by computer, i.e. automatically.

The first purpose of the first drying phase is to determine or ascertain the initial values for the automatic control. For this purpose, before the filling of the drying chamber 1, i.e. with the open drying chamber 1 empty, all measuring means for the said drying chamber 1 are tested for the appropriate performance of their function, the initial state being determined and logged via a control computer, i.e. fed into a variable-value store 3 associated with this latter. The number of ceramic blanks to be dried are then introduced into the drying chamber 1, after which the said drying chamber 1 is switched on, in order to heat and bring the inserted quantity of ceramic blanks to a temperature value υ this being done without any air, i.e. the ceramic blanks are heated by the provided circulating air, continuously moved in the drying chamber by motors of an air circulation device 4 with suitable bellows. When the motors of the air circulation device 4 are switched on, the load in a representative zone of the drying chamber 1 is automatically determined at the same time by the aid of an electronic dynamometric device 5, preferably consisting of pressure cells. From the value thus measured the control computer calculates the initial mass, the starting time then being determined and all values logged by feeding them into the variable-value store 3. The motors of the air circulation device 4 for the circulating air in the drying chamber 1 are operated cyclically in accordance with a control

program from a fixed-value store 6. This process continues until the drying chamber 1 is automatically switched off. A heat exchanger associated with the drying chamber 1 and not shown in the drawing is subjected by an associated adjusting valve V_1 for a freely programmable time t_1, which may range from zero to seven hours, to a programmable power P1, which may range from 0 and 100%.

After the expiry of this period the heat exchanger is set to a programmable power P2, which may range from 0 to 100%. This process is maintained until the average circulating air temperature of the drying chamber 1 has reached a programmable temperature $\upsilon 1$, which may range between 0 and 100%. When this temperature is reached the process time which has elapsed is determined, written in by feeding it into the variable-value store 3 and logged, the transition to the control conditions of the second drying phase then being effected.

The purpose of the second drying phase is the further heating of the ceramic blanks and the commencement of the removal of moisture by controlled air change in the drying chamber 1. The gradient of the humidity reduction is utilized as the guide value.

In the transition to the second drying phase the adjusting valve V1 is set to a programmable value P2, which may range from 0% to 100%, and the air change device, by means of an adjusting device V2, is further opened in programmable steps S1, which may range from 0 to 100%, and in intervals of time t_2 which may range from zero to a hundred minutes, until a programmable gradient of the humidity decrease G1, which may range from 0 to 5% of the moisture per second, is reached. From this moment onwards, of which the process time is logged by feeding it into the variable-value store 3, the adjusting device V2 is adjusted in small steps, for the purpose of maintaining the selected G1 value.

The second drying phase is completed by the residual moisture value $F_{(t)}$ having reached a programmable value F1, which may range from 0 to 15%.

The moist air leaving the drying chamber 1 is conveyed through an air outlet shaft above the roof. The air conveyed to the drying chamber is taken from a channel into which spent air from other drying chambers which at this moment are in the third drying phase and are giving off relatively dry warm air. The drying chamber 1 shown in the drawing symbolizes one of a number of drying chambers present. The process time which has elapsed when the value F1 is reached is logged by feeding it into the variable-value store 3. The purpose of the third drying process is to extract residual moisture from the ceramic blanks relatively rapidly and to complete the drying process under favourable conditions as regards energy consumption.

In the transition to this third drying phase the valve V1 is set to a programmable value P3, which may range from 0 to 100%, and the air change adjusting device V2 to a position L2, which may range from 0 to 100%.

With these parameters the drying process is continued until the residual moisture which can be calculated for the ceramic blanks has reached the value F2 which is programmahle in the fixed-value store 6 and which may range from 0 to 15%. The valve V1 is then set to 0 and the drying process continued until a residual moisture value F3, which may range from 0 to 15%, is reached.

The drying cycle is thus terminated, and the process time, residual moisture F3, date, time, temperature and drying chamber number are logged by input into the variable-value store 3, and the over-all sequence of operations in the drying process is then printed out in a printer or similar device 7.

The apparatus for the performance of the process consists of two measuring sensors 8 situated at different heights in the drying chamber. The measuring sensors used consist of resistance thermometers PT 100 or silicon diodes of which the UF (υ) value is evaluated, or else the specific semi-conductor thermometer probe B 511. To determine the moisture value in the ceramic blanks in the drying chamber 1 a column of the drying chamber structure, not shown in the drawing, contains a dynamometric device 5 in the form of electronic pressure cells.

Before the drying chamber 1 is given its charge of ceramic blanks the static supporting load Mst of the column is determined, the gross mass Mm being measured as an electrical magnitude after they have been so charged. During the drying process the reduction in the initial mass of the moisture removed is continuously ascertained. As the initial moisture fA is known the actual proportion of moisture fp is calculated by the control computer 2. The air and circulating air are controlled by valves 9 and 10, shown symbolically, in addition to the circulating air device 4. The servomotors are fitted with revertive signal pontentiometers, not shown, these being connected to the control computer 2.

The electronic control computer 2 comprises a central processing unit 11 and a fixed-value store 6, into which the programs are fed with a keyboard 12 via an adapter unit 13 and the central processing unit 11, a variable-value store 3, in which the intermediate values are entered from being printed out by a teleprinter or similar printer 7 at the end of the drying process, via an adapter unit 14 for the said teleprinter or similar printer 7, and adapter unit 15 for screen display and a screen unit 16.

The control computer 2 also includes an adapter unit 17 for adjusting elements such as valves 9 and 10 and the air circulation device

4, as well as an adapter unit 18, pick-ups such as dynamometric device 5, measuring sensors 8 or similar pick-ups.

The functions control by the control computer 2 is programmed and arranged in such a way that each time a servo-motor is actuated a revertive signal is emitted which differs in its level as a result of the pontentiometer connected with the adjusting valve and not shown in the drawing and is evaluated by the central processing unit.

CLAIMS

1. A process for drying ceramic blanks involving a multi-phase drying operation, the process comprising heating ceramic blanks in a drying chamber relatively slowly to a programmable temperature $\vartheta 1$ in a first drying phase without any air change in the drying chamber, effecting further heating of the ceramic blanks and initial removal of moisture by a controlled air change in a second drying phase, the gradient of the moisture removal being used as a guide value and in a third drying phase extracting the residual moisture still present relatively rapidly from the ceramic blanks and terminating the drying process under suitable energy consumption conditions, wherein the first drying phase commences with an empty open drying chamber, in such a way that by a control computer, measuring means in the drying chamber are tested for their operating efficiency, the initial state being determined and recorded, and then the ceramic blanks are introduced into the drying chamber and in order to heat them relatively slowly to a temperature ϑ without air change the operating means of the drying chamber are switched on, in which process, by an electrical dynamometer, the mass of the ceramic blanks within a representative zone in the drying chamber is automatically determined, the initial mass of the ceramic blanks being calculated from the values measured and the starting time determined and in parallel therewith the resulting values obtained are logged, and air circulation means in the drying chamber is operated cyclically by a control program until the drying chamber is automatically switched off, while a heat exchanger associated with the drying chamber and serving to heat the circulating air is subjected for a programmed time t_1 to a programmable power P_1 by an associated adjusting valve V_1, after the elapse of which said time the heat exchanger is set to a programmable power P_2, this process being maintained until the average circulating air temperature of the drying chamber has reached a programmable temperature $\vartheta 1$, and when this temperature is reached the process time which has elapsed is determined and logged and the control conditions of the second drying phase are commenced in such a way that the adjusting valve V_1 is set to a programmable value P_3, an air change device which is provided being opened further, by an adjusting device V_2, in programmable steps S_1 and at time intervals t_2, until the programmable gradient G_1 of the removal of moisture per unit time is reached, and from this moment, at which the process time is logged, the adjusting device V_2 is moved in small steps, in order to maintain the selected value for G_1, and the second drying phase is completed by the calculated residual moisture $F_{(t)}$ having reached a programmed value F_1, while the moist air leaving the drying chamber is conveyed through an air outlet shaft above the roof of the chamber, the air conveyed to the drying chamber being taken from a channel into which spent air from the other drying chambers which are then in the third drying phase and are giving off relatively dry warm air, and when the value F_1 is reached the process time is logged and the transition to the third drying phase commences by the valve V_1 being set to a programmable value P_4 and the adjusting device V_2 for the air change to a fixed position L_2, and the drying process is continued with these parameters until the residual moisture which can be calculated for the ceramic blanks has reached a programmable value F_2, after which the valve V_1 is adjusted to a zero value and the drying continued until residual moisture F_3 is reached, the drying cycle thus being terminated, while the process time, residual moisture F_3, date, time, temperature and drying chamber number are logged and printed out. 2. Process according to Claim 1, wherein time t_1 ranges from 0 to 7 and/or power P_1 ranges from 0 to 100% and/or P_2 ranges from 0 to 100% and/or temperature $\vartheta 1$ ranges from 0 to 100°C and/or power P_3 ranges from 0 to 100% and or t_2 ranges from 0 to 100 minutes and/or gradient G_1 ranges from 0 to 5% per hour and/or residual moisture F_1 ranges from 0 to 15% and/or power P_4 ranges from 0 to 100% and or value L_2 ranges from 0 to 100% and/or F_2 ranges from 0 to 15% and/or F_3 ranges from 0 to 15%.

3. A process for drying ceramic blanks involving a multi-phase operation substantially ss herein described with reference to the accompanying drawing.

4. Apparatus for carrying out the process defined in Claim 1, including as means for measuring the temperature in the drying chamber two thermometer probes provided at different heights in the drying chamber and for determining the humidity value in the ceramic blanks a column of the drying chamber atructure contains an electronic dynamometer device and as a data acquisition means an electronic control computer, and a chronometer of quartz accuracy, being connected with measuring means and control elements, and for controlling the air and air circulation and valves there are provided motors and servo-motors fitted with revertive signal potentiometers which are connected to the control computer,

and the electronic control computer includes a central processing unit, a fixed-value store for control and regulating programs, a variable-value store for control data, an adapter unit for a keyboard, an input keyboard, a screen display adapter unit and a screen display or a punctiform display, an adapter unit for a teleprinter and a printer, an adapter unit for regulating elements, an adjusting device, air circulation device, an adapter unit for measuring means and measuring sensors which central control apparatus is adapted to interrogate or activate the measuring means of a drying chamber complex and its adjusting devices at different times.

5. Apparatus according to Claim 4, wherein the electronic dynamometer device takes the form of electronic pressure cells.

6. Apparatus according to Claim 4 or Claim 5, wherein the said adapter unit for regulating elements is an adapter unit for valves and/or relays and/or motors.

7. An apparatus for drying ceramic blanks involving a multi-phase drying operation substantially as herein described with reference to the accompanying drawings.

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